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## Underestimation of obesity prevalence in Switzerland: comparison of two methods for correction of self-report

Faeh, D ; Braun, J ; Bopp, M

**Abstract:** **BACKGROUND/OBJECTIVE:** Studies using self-report may underestimate obesity prevalence because participants tend to overestimate their height, underestimate their weight and thus seriously underestimate their Body Mass Index (BMI). In order to find ways to adjust for this misestimation, we tested two correction methods for self-report by comparing the derived obesity prevalence rates with those based on measured height and weight. **METHODS:** We used individual data from six studies based on self-reported BMI (1980-2007,  $n = 46589$ ) and from five studies based on measured BMI (1977-2004,  $n = 20130$ ). All studies were population-based samples and carried out in Switzerland. We limited to men and women aged 35 to 74 years. Obesity was defined as  $BMI > \text{or} = 30 \text{ kg/m}^2$ . For correction method one, we used a lower BMI cutoff of  $29.2 \text{ kg/m}^2$  (for both sexes) for the definition of obesity; for method two, we adjusted weight and height (respecting age and sex) using equations that were derived from another population. Results were age-standardised. Differences were measured with a logistic regression model considering random effects. **RESULTS:** Adjustment of height and weight (method two) substantially approximated the BMI distribution based on unadjusted self-report to the BMI distribution based on measurement. In 2002/2003, obesity prevalence obtained with method two (men and women respectively: 16.3% and 13.0%) tended to be more similar to measured obesity prevalence (16.4% and 13.9%) than obesity prevalence obtained with method one (13.8% and 11.0%). **CONCLUSION:** Equation adjustment of self-reported weight and height provides an approximation of the real (measured) BMI distribution by sex and age and has advantages over the use of a universal lower cutoff level to adjust for self-report. However, to appropriately adjust for self-report, a Swiss-specific equation should be developed based on measured and self-reported heights and weights of the same individuals.

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# Underestimation of obesity prevalence in Switzerland: comparison of two methods for correction of self-report

David Faeh, Julia Braun, Matthias Bopp

Institute of Social and Preventive Medicine (ISPM), University of Zurich, Zurich, Switzerland

## Summary

**Background/objective:** Studies using self-report may underestimate obesity prevalence because participants tend to overestimate their height, underestimate their weight and thus seriously underestimate their Body Mass Index (BMI). In order to find ways to adjust for this misestimation, we tested two correction methods for self-report by comparing the derived obesity prevalence rates with those based on measured height and weight.

**Methods:** We used individual data from six studies based on self-reported BMI (1980–2007,  $n = 46\,589$ ) and from five studies based on measured BMI (1977–2004,  $n = 20\,130$ ). All studies were population-based samples and carried out in Switzerland. We limited to men and women aged 35 to 74 years. Obesity was defined as BMI  $\geq 30$  kg/m<sup>2</sup>. For correction method one, we used a lower BMI cutoff of 29.2 kg/m<sup>2</sup> (for both sexes) for the definition of obesity; for method two, we adjusted weight and height (respecting age and sex) using equations that were derived from another population. Results were age-standardised. Differences were measured with a logistic regression model considering random effects.

**Results:** Adjustment of height and weight (method two) substantially approximated the BMI distribution based on unadjusted self-report to the BMI distribution based on measurement. In 2002/2003, obesity prevalence obtained with method two (men and women respectively: 16.3% and 13.0%) tended to be more similar to measured obesity prevalence (16.4% and 13.9%) than obesity prevalence obtained with method one (13.8% and 11.0%).

**Conclusion:** Equation adjustment of self-reported weight and height provides an approximation of the real (measured) BMI distribution by sex and age and has advantages over the use of a universal lower cutoff level to adjust for self-report. However, to appropriately adjust for self-report, a Swiss-specific equation should be developed based on measured and self-reported heights and weights of the same individuals.

**Key words:** obesity; body mass index; measured and self-reported weight and height; cutoff; adjustment; Switzerland

## Introduction

In most countries, national prevalence of obesity stems from self-reported height and weight. These rates mostly underestimate real figures because study participants tend to overestimate own height and underestimate own weight [1–3]. This may also apply to Swiss Health Survey (SHS) data, although its results reasonably delineate obesity trends over time [4]. Obesity prevalence is comparably low in Switzerland, but there are many persons with self-reported Body Mass Index (BMI) little below obesity threshold (BMI = 30 kg/m<sup>2</sup>) [4]. This frequency distribution is very sensitive to small shifts which may lead to a particularly high proportion of 60% of misclassified (measured) obese individuals [4]. Such misclassifi-

cation distorts the relationship between obesity and disease or death [5].

In order to overcome misreport of height and weight, several adjustment equations have been developed [6–9]. An attempt with a lower cutoff BMI of 29.2 kg/m<sup>2</sup> instead of 30 kg/m<sup>2</sup> for the definition of obesity has been made with data of the general population of Geneva [10]. This approach may however have several limitations [11]. Unfortunately, for Switzerland as a whole, no representative measured data on height and weight are available. Except for the Geneva study, there is also a lack of adequate measurements assessed in the same individuals who reported height and weight [10]. Therefore, for national estimates, ad-

justment is only possible with equations derived from other populations. Since misreporting of height and weight varies between cultures, such equations may only be applicable with reservation to other populations [1, 12].

Our aim was to evaluate the performance of a

lower universal cutoff level vs adjustment equations derived from an Australian population when used for Swiss self-reported data. We compared corrected obesity prevalence and adjusted BMI distribution with results based on measured height and weight.

## Participants and methods

Self-reported height and weight from six nationally representative health surveys cover the period between 1982 and 2007: SOMIPOPS (Socio-Medical Indicators for the Population of Switzerland, 1982, n = 2749, 48% women) [13], IGIP (Interkantonaes Gesundheitsindikatoren-Projekt, 1988, n = 1532, 56%) [14] and the four Swiss Health Surveys (SHS, 1992, n = 8983, 55%; 1997, n = 7662, 56%; 2002, n = 13 156, 55%; 2007, 12 430, 55%) [15, 16]. The studies with self-report were representative for the whole of Switzerland, except IGIP, which was representative for five cantons (ZH, BE, VD, GE, TI). The participation rate was 73%, 70%, 71%, 60%, 64%, 66% for SOMIPOPS, IGIP, and SHS 1–4 respectively.

Adjustment of self-reported height and weight was made with equations respecting age and sex and based on a representative Australian population from 1995 [6]. The equation used in our study is based on a simpler version which does not respect age, men: corrected BMI =  $(1.022 \times \text{weight} + 0.07) / (0.00911 \times \text{height} + 0.1375)^2$ ; women: corrected BMI =  $(1.04 \times \text{weight} - 0.067) / (0.00863 \times \text{height} + 0.2095)^2$ . Since in Switzerland the difference between measured and self-reported height and weight depends on age, we preferred to use the age-dependent version [4]. This version of the equation has not been published but can be derived from an Excel-sheet which can be downloaded (<http://www.health.usyd.edu.au/economics/resources/supplementary.php>). We directly applied the formulae from the sheet to our height and weight data in Excel and transferred the equation adjusted weight and height to the statistic program. For the BMI cutoff correction we used the proposed universal threshold of 29.2 kg/m<sup>2</sup> instead of 30 kg/m<sup>2</sup> irrespective of sex and age [10].

For comparison, we used measured height and

weight which were obtained with standardised procedures from population-based local or regional studies carried out in Switzerland between 1977 and 2003: the NRP 1A (National Research Project 1A, 1977, n = 5148, 54%) study [17], the three MONICA studies (Monitoring of Trends and Determinants in Cardiovascular Disease, 1984, n = 2987, 49%; 1988, n = 2971, 49%; 1992, n = 2839, 51%) [18] and the CoLaus study (Cohorte Lausannoise, 2003, n = 6185, 52%) [19]. The studies with measurements were representative for five cities (Aarau, Solothurn, Nyon, Vevey, Lugano), three cantons (VD, FR, TI) and the city of Lausanne and the participation rate was 59%, 57%, 61%, 53%, 42% for NRP 1A, MONICA 1–3 and CoLaus respectively.

We restricted our analysis to age range 35 to 74 and excluded individuals with missing weight or height. In order to compare obesity prevalence based on 1) equation adjusted self-report, 2) self-report with cutoff of 29.2 kg/m<sup>2</sup>, 3) self-report with cutoff of 30 kg/m<sup>2</sup> with obesity prevalence based on measurement (reference), a logistic regression model for obesity was used. In this model, we included year of survey and a categorical variable (measurement or self-report). We also included a random effect for survey, thus accounting for potential clustering within each study. Since the values obtained from the two correction methods are transformations of the same original value (stem from the same measurement of the same individual), the three versions of self-report should not be included in one joint model. Therefore three different models were fitted for comparing the odds for measured obesity vs that for each of the three self-report versions. Analyses were performed with Stata 10.1 (Stata Corp., Texas, USA).

## Results

Figure 1 illustrates the aggregated distribution of BMI derived from studies with measured (black solid) and self-reported (grey dashed) estimates and the BMI distribution after adjustment of self-reported height and weight using the equation (green dashed/dotted). In men, the distribution was more “Gaussian”, while in women the distribution was more flat and right-skewed. Adjustment of height and weight led to an approximation to the distribution of measured BMI, particularly in women.

Prevalence rates and regression lines of obesity in surveys with measurement (black squares and solid lines) and self-report (grey squares and dashed lines) are shown in figure 2 A and B. With adjustment (green triangles and dashed/dotted lines) there was an approximation of all self-re-

ported surveys towards measured surveys. As shown in figure 2 B, the green and the black line are parallel, suggesting that equation-adjusted obesity prevalence rates follow the same increase as measured obesity prevalence and not that of self-reported obesity. According to the equation-adjusted estimates, obesity prevalence stagnated between 2002 and 2007 at about 16% and 13% in men and women respectively. With cut-off correction (yellow crosses and dashed/dotted line), the approximation appeared less good than with age and sex-specific adjustment of height and weight and the resulting slope was less steep. Timely comparable, large and recent studies with measurement (2003, men and women respectively: 16.4% and 13.9%) and self-report (2002, 10.4% and 8.6%) showed very similar obesity prevalence

Figure 1

Distribution of BMI in all studies with measured (black), unadjusted (grey dashed) and equation-adjusted (green, dashed/dotted) self-reported BMI, by sex.

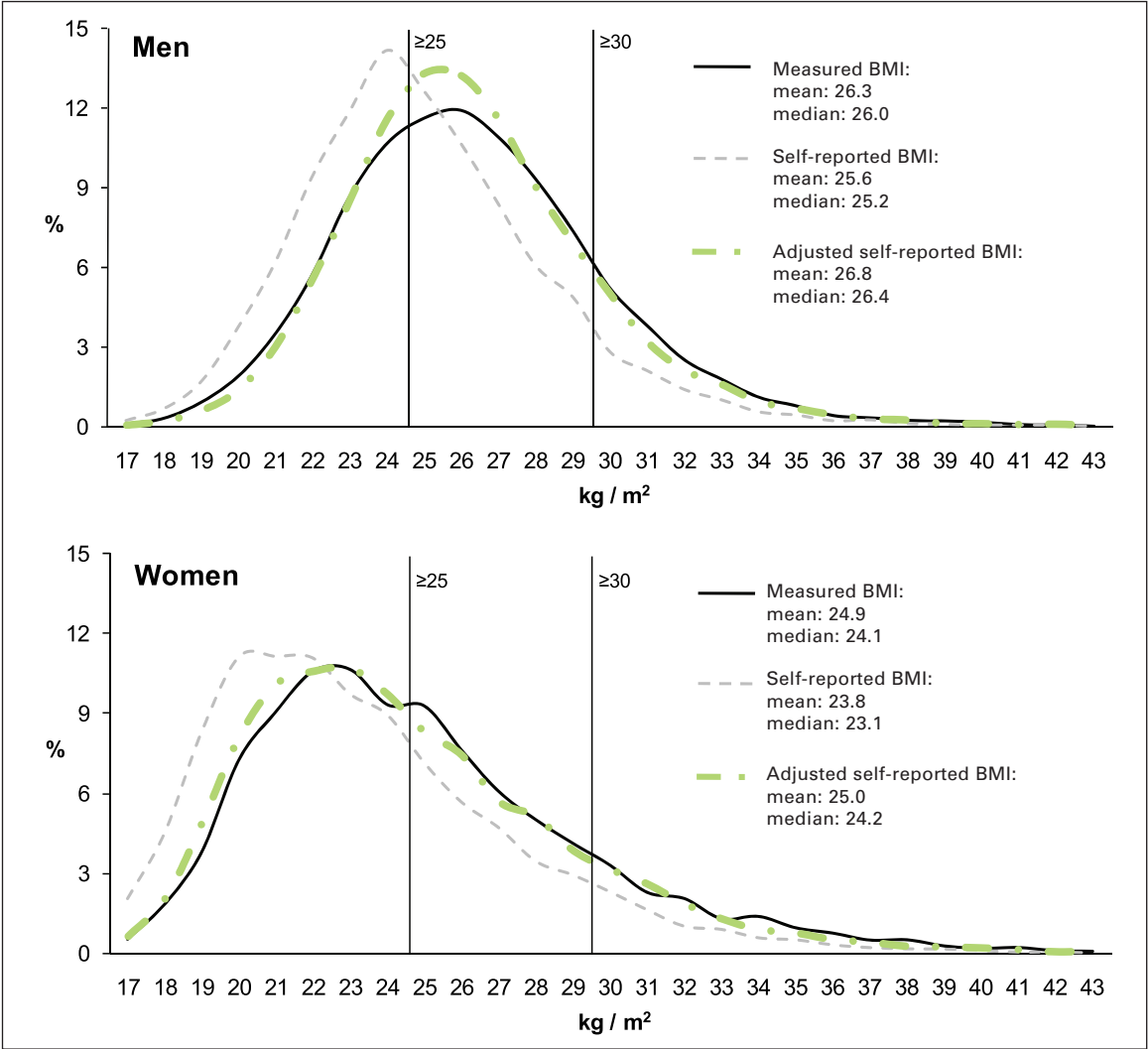
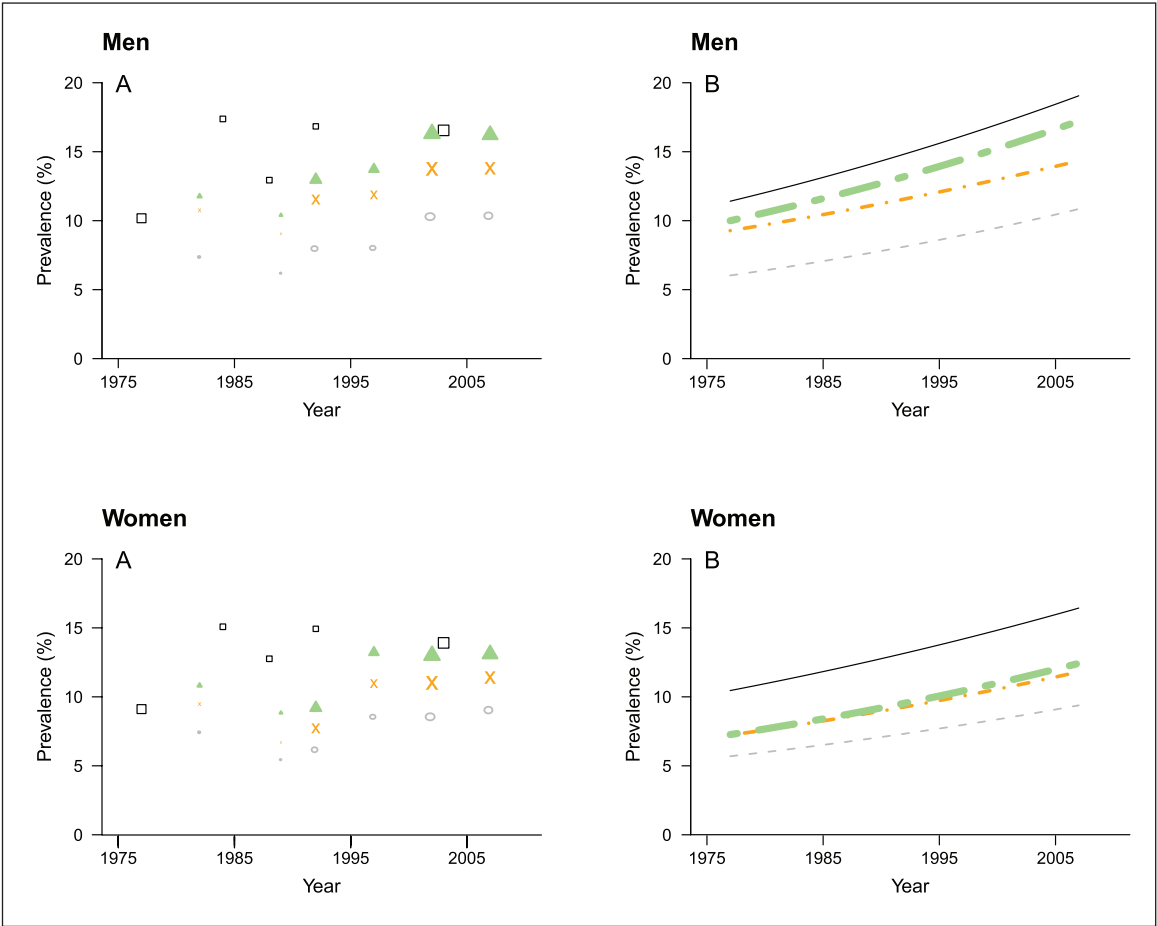


Figure 2

Mean prevalence (%) of obesity by study (A) and according logistic regression lines (B).



Measurement: black squares and solid lines; unadjusted self-report: grey squares and dashed lines; equation-adjusted self-report: green triangles and dashed/dotted bold lines; cutoff corrected self-report: orange crosses and dashed/dotted lines) by sex.

after adjustment of self-report (16.3% and 13.0%), whilst using a lower cutoff provided lower estimates (13.8% and 11.0%). Since all three versions of self-report (the original and the two corrected) are based on the same information, a test for statistical significant differences between these point estimates is not feasible.

The table shows the results of the random effects logistic regression models. The odds ratios represent the ratio between the odds for obesity of each of the three versions based on self-report and the odds for obesity based on measurement (reference). An odds ratio of 1 would stand for exact

agreement with the reference. Equation-adjusted self-report tends to approximate measurement better than self-report with cutoff 29.2 kg/m<sup>2</sup> although none of the correction methods could fully approximate the measured values. The approximation of both correction methods was better in men than in women. In men, between the odds for obesity based on equation-adjusted self-report and the odds for obesity based on measurement, there was no statistically significant difference. Almost full approximation could be obtained with the alternative cutoffs which have been proposed earlier [11].

**Table 1**

Odds ratios for obesity between measurement and the three versions of self-report by sex.

Method	Men			Women		
	OR	95% CI	P	OR	95% CI	P
Measurement (BMI ≥30 kg/m <sup>2</sup> )	1			1		
Self-report (BMI ≥30 kg/m <sup>2</sup> )	0.51	(0.43–0.60)	<0.001	0.52	(0.44–0.62)	<0.001
Corrections						
Self-report (BMI ≥29.2 kg/m <sup>2</sup> )	0.75	(0.64–0.88)	<0.001	0.68	(0.57–0.81)	<0.001
Equation-adjusted self-report (BMI ≥30 kg/m <sup>2</sup> )	0.87	(0.75–1.02)	0.083	0.70	(0.59–0.83)	<0.001
Alternative cutoffs						
Self-report (BMI ≥28.6/≥28.2 kg/m <sup>2</sup> )	0.99	(0.85–1.15)	0.870	0.95	(0.79–1.14)	0.602

## Discussion

National obesity prevalence rates in Switzerland stem from self-reported height and weight which may lead to an underestimation of real (measured) figures. To account for this, we used two correction methods for BMI: a universal cutoff and an age- and sex-dependent adjustment equation. Both methods led to a conservative approximation to results obtained from studies using measured height and weight.

It was somewhat surprising that obesity prevalence derived from adjustment equations was quite similar to prevalence obtained with measured estimates. One could expect that such equations would only be applicable to the datasets in which they are generated [3, 6]. In fact, there are large differences in misestimation of own height and weight between cultures [1, 12]. In contrast, using the universal cutoff of 29.2 kg/m<sup>2</sup> had several disadvantages [10]: Firstly, there was still a substantial underestimation of obesity prevalence when compared to studies with measurement. Secondly, using the universal cutoff resulted in a stronger underestimation in women than in men and changed the obesity trend over time in women. A rough approximation suggested that possible cutoffs could rather be around 28.6 kg/m<sup>2</sup> in men and 28.2 kg/m<sup>2</sup> in women (see table 1), but trend distortion cannot be avoided when using universal cutoffs [11]. Thirdly, a simple cutoff correction precludes an estimation of the underlying BMI distribution or the prevalence of other BMI categories such as overweight (BMI 25–29.9 kg/m<sup>2</sup>) or severe obesity (BMI ≥35 kg/m<sup>2</sup>).

We only adjusted for sex and age [6]. Further consideration of smoking and socioeconomic status could improve approximation, but such information is not always available [6]. A simple and always feasible way of adapting adjustment to cultural peculiarities could be to look at reporting patterns of end digits. Between cultures there are substantial differences in preferences for rounding own height and weight to a number ending with a specific digit (e.g. 0 or 5) [20, 21]. This preference is related to spoken language rather than to nationality and may be especially relevant in culturally heterogeneous countries.

Another factor that complicated adjustment for self-report bias is that changing awareness of obesity over time (i.e. increasing social desirability bias towards lean body weight) may influence participants propensity to over- or underreport weight [6, 21]. Therefore it might be necessary to continuously adapt adjustment equations used in the very same country. However, the differences between obesity prevalence rates from measurement and self-report (in particular the adjustment equation version) appeared quite systematic and constant over time in Switzerland, but this may not apply to countries where obesity prevalence has changed faster and more strongly.

In the US, self-reported weight from telephone interviews appears to be more strongly biased than that from in person interviews. However, to our knowledge, no study has assessed whether persons report their weight and height more accurately in a clinical setting (e.g. medical



practice). Based on our Swiss data, it cannot be expected that self-report from a clinical setting would be less biased than self-report from epidemiological studies. As reported, we have no reason to believe that persons living in Switzerland intentionally underestimate their weight and overestimate their height [4]. It appears thus important for physicians to measure weight and height (and not simply ask for it) and to calculate their patients' BMI based on measured estimates.

Our study has several limitations. The studies included were somewhat heterogeneous with respect to geographical coverage and representativeness. However, data from the four SHS, which covered entire Switzerland, showed no substantial regional difference in mean BMI. Pooling studies of different time periods (fig. 1) may be critical. However, by age standardising we could overcome the period effect. Moreover, separate analyses excluding foreign participants only marginally differed from the non-adjusted estimates. We thus decided not to use them to avoid arbitrary decisions for pooling. Non-participants in surveys may be more frequently obese than participants [22]. Participation rates tended to be lower in studies

with measured than in those with self-reported BMI. Thus, difference in obesity prevalence between the two types of studies could be slightly biased.

We conclude that using an equation to adjust self-reported height and weight provided a reasonable estimation of the BMI distribution and obesity prevalence and had several advantages over the use of a universal lower cutoff BMI. However, our analysis also stressed the need for national data to calculate a Swiss-specific correction equation. This could be obtained with a validation study assessing measured and self-reported weight and height of the same person, e.g. by measuring weight and height of a randomly selected subset of participants in the Swiss Health Survey. Including additional information, e.g. preference for end-digits may further improve the correction.

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*Correspondence:*

*David Faeh*

*Hirschengraben 84*

*CH-8001 Zürich, Switzerland*

*E-Mail: david.faeh@ifspm.uzh.ch*

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